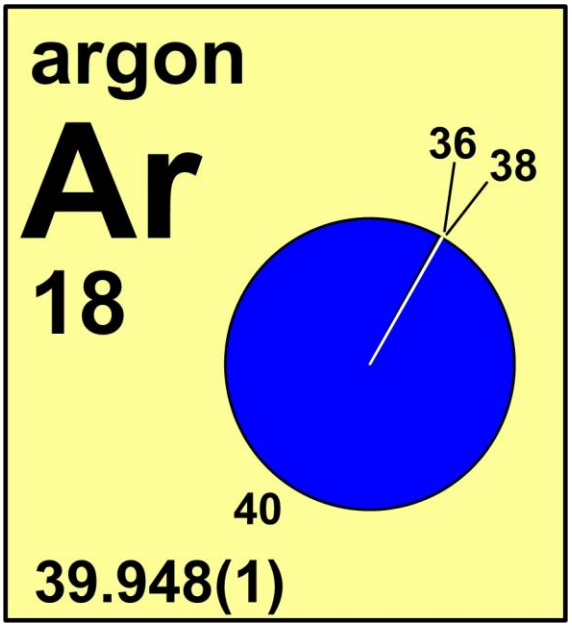
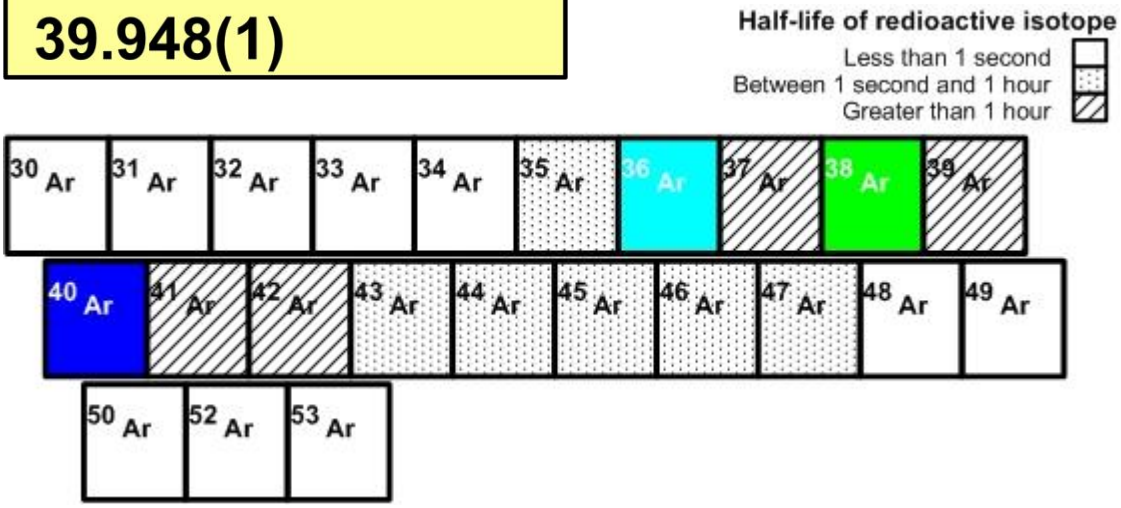
## argon




| Stable isotope | Atomic mass* | Mole fraction |
|---|---|---|
| $^{36}$Ar | 35.967 545 11 | 0.003 365 |
| $^{38}$Ar | 37.962 7324 | 0.000 632 |
| $^{40}$Ar | 39.962 383 12 | 0.996 003 |

* Atomic mass given in unified atomic mass units, u.




### Important applications of stable and/or radioactive isotopes

Isotopes in geochronology

1) Argon is used to date various rock samples, especially volcanic rocks, using two different techniques.
    a. The first technique is potassium-argon dating (K-Ar), which is possible because $^{40}$K decays at a constant rate and produces stable $^{40}$Ar. By determining how much $^{40}$Ar has been produced, it is possible to determine an approximate age for rocks.
    b. The second technique, which is newer and more accurate for dating, is the $^{40}$Ar/$^{39}$Ar technique that allows a sample to be irradiated to produce $^{39}$Ar from $^{39}$K. The $^{40}$Ar/$^{39}$Ar ratio is then determined and from this, the approximate age of the rock can be found.

Figure 1: An Argon mass spectrometer in a lab dedicated for $^{40}Ar/^{39}Ar$ measurements.

Isotopes as environmental tracers

1) Argon's non-reactive properties make it an ideal tracer. The $^{40}Ar/^{36}Ar$ ratio allows scientists to learn more about the evolution of the atmosphere and provides insight about the orogenic evolution of the earth by studying the ratios over time.
    a. For example, the $^{40}Ar/^{36}Ar$ ratio can be indicative of the movement, mixing, and origins of volcanic materials as well as crust/mantle interactions.
2) The $^{40}Ar/^{39}Ar$ ratio is sensitive to temperature and can therefore, provide information about geologic temperature history.
3) $^{40}Ar$ can also be used in conjunction with other elements to determine past temperatures.

Figure 2: Studying the ratios of argon isotopes can provide insight into the origins and movement of magma.

Isotopes in hydrology

1) The study of $^{37}Ar$, $^{39}Ar$ and $^{40}Ar$ concentrations in groundwater can help determine information about the in situ production and release of these isotopes from rocks and other sources into groundwater as well as determine the age of the groundwater.
2) $^{40}Ar/^{36}Ar$ ratios can be studied in groundwater to determine hydrological information, such as rates of crustal degassing and determining groundwater age.

Figure 3: The Great Artesian Basin, Australia, was a site of argon isotope analysis where $^{40}Ar/^{36}Ar$ ratios were studied to determine amounts of excess $^{40}Ar$ and find rates of crustal degassing.

Isotopes in medicine

1) $^{38}K$, which is produced by a nuclear reaction involving $^{38}Ar$ and $^{40}Ar$ as targets, is a widely used blood flow tracer. Because $^{38}Ar$ is more expensive, $^{40}Ar$, which also offers many additional advantages as a target, is more commonly used to produce $^{38}K$ for medical purposes.

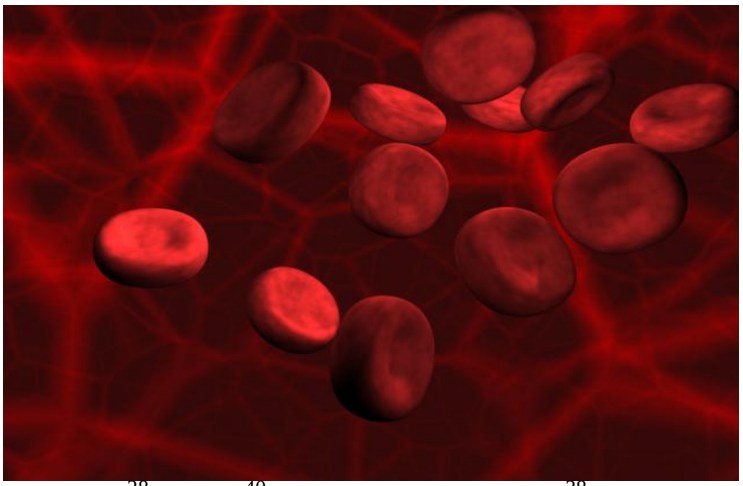


Figure 4: $^{38}Ar$ and $^{40}Ar$ are used to produce $^{38}K$, which is used as a blood flow tracer.

Isotopes in industry

1) $^{41}Ar$, which is produced by $^{40}Ar$, is used as an industrial gas flow tracer since its inert properties, half life, and gamma radiations make it well suited for this purpose.

Figure 5: Argon Regulator.